News for September 4, 2008

Scientists Find Our Eyes Evolved for 'X-Ray' Vision
The advantage of using two eyes to see the world around us has long been associated solely with our capacity to see in three dimensions. Now, a new study by scientists at Rensselaer Polytechnic Institute in New York and Caltech has uncovered a truly eye-opening advantage to binocular vision: the ability to see through things.

Caltech Invention Earns R&D 100 Award
Research done at the California Institute of Technology has been honored with *R&D* magazine's *R&D* 100 Award. The award recognizes significant new technologies from the past year. Making the list this year was work conceived by Morteza Gharib (PhD '83), the Hans W. Liepmann Professor of Aeronautics and professor of bioengineering at Caltech, and by his team, including Emilio Graff (PhD '07) and postdoctoral fellow Francisco Pereira. The team designed a three-dimensional camera with a vast array of possibilities, ranging from 3-D movement tracking for rehabilitation to underwater surveillance. Their invention, the Volumetric 3-Component Velocimetry Video (V3V) System, has been licensed and marketed by TSI Inc., a Minnesota-based company that designs and manufactures precision instruments used to measure flow, particulates, and other key parameters.

Herb Keller Memorial Workshop
A daylong event in memory of Herbert B. Keller, Caltech professor of applied mathematics, emeritus, will be held from 8 a.m. to 9 p.m. on Friday, September 12, in 101 Guggenheim Lab (the Lees-Kubota Lecture Hall). Keller retired in 2000 but remained an active researcher, attending seminars, workshops, and conferences related to his fields of interest until his death in January 2008. He is credited with pioneering developments in bifurcation theory, and his methods are the basis for computer software that is widely used to derive numerical solutions to nonlinear equations. Click **here** to view the full workshop schedule.

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Dr. Shinsuke Shimojo

PASADENA, Calif.-- The advantage of using two eyes to see the world around us has long been associated solely with our capacity to see in three dimensions. Now, a new study by scientists at Rensselaer Polytechnic Institute in New York and the California Institute of Technology (Caltech) has uncovered a truly eye-opening advantage to binocular vision: the ability to see through things.

Most animals--fish, insects, reptiles, birds, rabbits, and horses, for example--live in non-cluttered environments like fields or plains and have eyes located on either side of their head. These sideways-facing eyes give an animal panoramic vision--the ability to see in front and behind itself.

Humans, primates, and other large mammals like tigers, however, have eyes pointing in the same direction. These animals evolved in cluttered environments, such as forests or jungles. Because of their forward-facing eyes, these animals lose the ability to see behind themselves, but they gain a type of X-ray vision that maximizes their ability to see in leafy environments.

So argues Mark Changizi, formerly a postdoctoral scholar at Caltech who is now an assistant professor of cognitive science at Rensselaer, in a new paper that appeared August 28 in the online issue of the Journal of Theoretical Biology. Changizi conducted the research in collaboration with Caltech professor of biology Shinsuke Shimojo.

All animals can see at least parts of the world simultaneously with both eyes. The size of this area, called the binocular region, grows larger as eyes become more forward facing. The binocular region is what makes X-ray vision possible.

Demonstrating this X-ray ability is fairly simple: hold a pen vertically and look at something far beyond it. If you first close one eye, and then the other, you'll see that in each case the pen blocks your view. If you open both eyes, however, you can see through the pen to the world behind it.

"Our binocular region is a kind of 'spotlight' shining through the clutter, allowing us to visually sweep out a cluttered region to recognize the objects beyond it," says Changizi. "As long as the separation between our eyes is wider than the width of the objects causing clutter, we can generally see through it."

To identify which animals have this impressive power, Changizi and Shimojo studied 319 species across 17 mammalian orders. They discovered that eye position depends on two variables: the clutter in an animal's environment, and the animal's body size relative to the objects creating the clutter.

In non-cluttered environments--either non-leafy surroundings, or those where the cluttering objects are larger than the separation between the animal's eyes--animals tend to have sideways-facing eyes.

"Animals outside of leafy environments do not have to deal with clutter no matter how big or small they are, so there is never any X-ray advantage to forward-facing eyes. Because binocular vision does not help them see any better than monocular vision, they are able to survey a much greater region with sideways-facing eyes," Changizi explains.

However, in cluttered environments--leafy surroundings where the cluttering objects are smaller than the separation between an animal's eyes--animals tend to have a wide field of binocular vision, and thus forward-facing eyes.

"This X-ray vision makes it possible for animals with forward-facing eyes to visually survey a much greater region around themselves than sideways-facing eyes would allow," he says.

In such a cluttered environment, the animals' size also matters, Changizi says: "The larger the animal, the more forward facing its eyes will be, to allow for the greatest X-ray vision possible, to aid in hunting, running from predators, and maneuvering through dense forest or jungle."

While human eyes have evolved to be forward facing, Changizi and Shimojo suspect we might actually benefit more from sideways-facing eyes because we live in relatively non-cluttered environments.

"In today's world, humans have more in common visually with tiny mice in a forest than with a large animal in the jungle. We aren't faced with a great deal of small clutter, and the things that do clutter our visual field, like cars and skyscrapers, are much wider than the separation between our eyes, so we can't use our X-ray power to see through them. If we froze ourselves today and woke up a million years from now, it might be difficult for us to look the new human population in the eye, because by then their eyes might be facing sideways."

"This study is nicely consistent with my earlier work with Ken Nakayama in the 1980s, where we provided evidence against the classical notion of binocular vision in that the simultaneous stimulation of two eyes is not critical for binocular integration of visual inputs and stereopsis," says Shimojo.

"Rather," Shimojo adds, "the eye-of-origin information is critical. That is, areas that are viewed by only one eye, and the eye they are viewed by, are very important for an integrated perceptual interpretation of the 3-D environment with the two eyes. This means, also against the classical notion, that the monocular (binocularly unpaired) inputs are, when ecologically valid, not suppressed as noise by interocular suppression. This new piece of work by Mark nicely extends our earlier work into a more comparative, evolutionary, and computational perspective."

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